Exhibit S

SECTION 02140

GEOTECHNICAL AND STRUCTURAL MONITORING INSTRUMENTATION

PART 1 - GENERAL

1.01 SUMMARY

A. Purpose: The purpose of this work is to generate reliable data to be used to foresee problems of structure, utility, equipment and ground movement. It is also intended to provide a written record which can be used to resolve disputes related to settlement and structural damage.

B. Scope: The work will include, but is not limited to, furnishing, installing, calibrating, monitoring, maintaining and removing all necessary equipment and apparatus for a complete monitoring system.

C. Division of Responsibility: The Contractor's field instrumentation specialist must be responsible for purchasing, installing and obtaining data from the ground instrumentation and the structural instrumentation. The Contractor must be responsible for providing access to instrument locations throughout construction.

D. Related Sections:

Section 02160:	Control of Water
Section 02202:	Trenching and Backfilling
Section 02316:	Rock Blasting, Excavation and Removal

Except as modified herein, the work must be performed in accordance with the applicable requirements of the Special Provisions, New Castle County (NCC) Supplemental Specifications, NCC Standard Specifications for Construction, DelDOT Special Provisions and this Section.

E. Description of Instruments:

1. Cased deep benchmarks are benchmarks founded at an elevation below the bottom of the excavation and which are isolated from the surrounding soil by an outer casing. Cased deep benchmarks are used as control benchmarks for determining the elevation of all other instruments.

Note: Additional information relevant to this section is provided as the answers to Questions 55 and 56, in Addendum 5.

2. Surface settlement markers are markers placed on structures. Surface settlement markers are monitored by optical survey methods to determine vertical displacements during construction.

3. Inclinometer casing in earth is an instrument installed within vertical holes located entirely in the in-situ soil. A probe, lowered within the inclinometer casing is used

to monitor horizontal displacements of the soil behind the Temporary Earth Retention Structures at depth during construction.

4. Tiltmeter plates are instruments installed on structures to monitor angular rotation of the structure during construction. The plates are monitored by placing a portable tiltmeter on the plate.

5. Crack monitoring pins are two pins; one pin placed on each side of a crack that can be measured with calipers to determine accurate changes in crack dimensions.

6. Seismograph is a device used to detect and measure the intensity, direction and duration of ground movements. These typically use microphones and triaxial geophones to record the data during a blast event.

7. Open Standpipe Piezometers consist of perforated plastic pipes installed to boreholes drilled to depths below the local ground water level. Ground water flows into the perforated pipe. As ground water levels change due to construction excavation seepage, construction dewatering, or other effects, the level of the water inside the perforated plastic pipe changes to provide a simple indication of the approximate ground water level in the area.

1.02 COOPERATION BETWEEN CONSTRUCTION CONTRACTOR AND FIELD INSTRUMENTATION SPECIALIST

A. Success of the field instrumentation effort will require close cooperation between the Contractor and the field instrumentation specialist. Prior to the start of construction, the field instrumentation specialist must meet with the Contractor so that all parties understand the nature and extent of the instrumentation program. The Contractor must cooperate with the field instrumentation specialist by providing access to instrument locations and by preventing damage to ground instruments during construction. If such damage occurs, the Contractor must pay for the instruments to be replaced.

B. Contractor and field instrumentation specialist shall also cooperate with the Engineer and/or authorized project stakeholders, such as DelDOT and utility companies. Such cooperation shall include access to the instruments for independent readings and/or access to the field readings and logs of the instrumentation specialist during field readings to allow independent record keeping of readings in the field.

1.03 SUBMITTALS

A. Prior to proceeding with the work, submit the following:

1. Qualifications of Personnel specified in Article 1.04 herein.

2. Schedule and procedures: Proposed schedule and detailed procedures for installing and monitoring all instruments and performing the other work of this section.

3. Instrument materials information: Manufacturer's literature including descriptions and details of all instrumentation proposed for use, including sensors, read-outs, software, wiring, curb boxes, grout, epoxy and protective covers.

4. Documentation of preconstruction and post construction survey.

B. Instrument Monitoring Data:

1. Three copies of original field notes and data, on forms approved by New Castle County (NCC), without delay during the working shift in which observations have been made.

2. Reduced notes within 24 hours after observations have been made.

3. Immediate report of vertical movements detected.

4. Graphical plots, on forms approved by NCC, of all settlement data within 24 hours after observations have been made.

C. Daily Logs: A daily log of major construction events and observations on forms approved by NCC. Include in the daily log at least the following:

1. Detailed excavation and construction records for Temporary Earth Retention Structures.

2. Installation record with location, type and time for internal braces including preload records.

3. Incidence of excessive ground loss through the excavation support wall, boulders, groundwater flow, instability or other unusual events.

4. Location and elevation of significant soil strata boundaries encountered during excavation and brief soil descriptions.

5. Construction loading in the vicinity of instrumentation.

6. Temperature, rain-gauge readings and notation of heavy rainfall.

D. Survey Notes: Three copies of original field notes of survey-control surveying.

E. Working Drawings: Working drawings and reports proposing and summarizing instrumentation installations.

1. Prior to any instrumentation installation, working drawings shall be submitted showing the location and elevation of surface bench marks, as well as the location, tip elevation, and surface elevation of all deep cased bench marks required to provide the survey control specified herein. Establish bench marks in areas outside of construction operations and staging, such that all elevation surveys can be performed with no sight distance greater than 200 feet. Locate bench marks outside possible range of ground movement caused by

construction. CONTRACTOR shall have a Professional Engineer, licensed in the state of Delaware, prepare a submittal to be reviewed by the ENGINEER.

2. Prior to any instrumentation installation, drawings and plans shall be submitted showing proposed location of all instruments, monitoring frequency and plan of installation. CONTRACTOR shall have a Professional Engineer, licensed in the state of Delaware, prepare a submittal with the locations and numbers of instruments is to be reviewed by the ENGINEER.

3. After instrumentation installation and initial monitoring are completed, working drawings shall be submitted summarizing the installation of each instrument and monitoring point. The information shown on these working drawings shall include, but not be limited to, the following data:

   (a) Instrument identification numbers and locations, with initial elevations, station and offsets, and coordinates, as applicable for each instrument.

   (b) As-built installation details of each instrument, including depths, lengths, elevations, materials used, and dimensions of key elements.

   (c) A separate statement describing the procedure used for the installation of each instrument.

F. Response Action Plan

1. The Response Action Plan shall identify the specific anticipated actions or example actions to be implemented at each response action level for each element of the Work which may cause movement or vibration to exceed the response action levels and shall include as a minimum the measures described above under Response Action Levels, all other potential response measures envisioned by the Contractor, plus the names of the responsible person of the Contractor's team for each element of the Work. The Response Action Plan, as a minimum, shall also identify all key structures and utilities throughout the Site and their owners and responsible contact persons, as well as define the Contractor team person party responsible for each structure. The Response Action Plan will also identify the resources required for each Alert Threshold response and Upset Limiting response, including the notification required if action is taken at each level.

2. The Response Action Plan shall be updated by the Contractor from time to time as required by the Engineer based upon performance in field and changes in responsible persons as the project proceeds.

3. At a minimum, one copy of the Response Action Plan shall be maintained present at each excavation area and at Contractor's Office. The Response Action Plan shall be distributed to the Engineer and shall, at a minimum, include the following:

   a. Name(s), telephone number(s), and locations(s) of person(s) responsible for implementation of contingency plans;

   b. Materials, equipment and supplies required to implement contingency plans;

c. Location at work site of all necessary materials, equipment and supplies required to implement the contingency plans;

d. Each type of anticipated remedial method proposed to stabilize soil and/or structure movements. Include basis for determining proposed actions;

e. Step-by-step procedure for performing work involved with contingency plans;

f. Clear identification of objectives of contingency plans and methods to measure success of contingency plans

1.04 QUALITY ASSURANCE

A. Qualifications of Personnel:

1. Field Instrumentation Specialist: The Contractor must employ the services of a qualified field instrumentation specialist. Perform instrument installation and monitoring work under the direct supervision of the instrumentation specialist. The instrumentation specialist must be a licensed Professional Engineer or a licensed Professional Geologist licensed in the state of Delaware, having at least three years of recent experience in the design, installation, and monitoring of instrumentation similar to the types specified. Persons not meeting the registered professional engineer or geologist requirement will be considered on the basis of extensive experience and technical knowledge as demonstrated by resumes, personal interviews and if that person is supervised by a professional engineer or geologist. NCC reserves the right to reject any person deemed to be insufficiently qualified.

a. Employ qualified technicians with at least one year previous experience in installation of instruments of the type specified.

b. Employ qualified technicians for instrument monitoring with at least one year previous experience in monitoring of instruments of the type specified.

c. Employ a Land Surveyor, licensed in the state of Delaware, thoroughly experienced in instrument monitoring of the type specified, to supervise and direct instrument monitoring technicians and to be responsible for instrument monitoring.

2. Survey Control:

a. Employ qualified technicians with previous experience in performing control surveying of type specified.

b. Employ a Surveyor, licensed in the state of Delaware, thoroughly experienced in survey control of type specified to supervise and direct survey-control technicians and to be responsible for survey control.

B. Tolerances:

1. Establish the coordinates of survey-control monuments to 0.001 foot.

2. Establish the coordinates of survey-control baseline traverse points to 0.001 foot.

3. Establish the coordinates of cased deep benchmarks to 0.001 foot.

4. Establish the initial elevation of surface settlement markers to 0.001 foot.

5. Establish the initial coordinates of the top of inclinometer casing to 0.005 foot.

6. Establish initial elevation of the top of the inclinometer casing to 0.001 foot.

7. Establish the initial coordinates of all other instruments to 0.1 foot.

8. Record the subsequent elevations of surface settlement markers to 0.005 foot.

9. Record the subsequent horizontal movements of the top of inclinometer casing, perpendicular to the excavation support wall, accurate to 0.01 foot.

10. Install inclinometer casing within two degrees of vertical for the entire length.

11. Align the longitudinal grooves of the inclinometer casings to within two degrees of parallel and perpendicular to the excavation.

12. Record readings of crack monitoring pins to 0.01inch.

C. Site Conditions: Before starting work, and after completion of work, survey the conditions of existing structures taking photographs to record existing settlement and cracking of walls, foundations and slabs. Prepare a list of such damages, verified by dated photographs, and signed by the Contractor and others conducting the investigation. Obtain photographic or video documentation of pre-construction conditions where applicable and where allowed by property owners. A preconstruction survey shall be performed on all structures and facilities that are at risk for being affected by construction operations. At a minimum, all structures/facilities/roadways within 200 feet shall have a preconstruction survey performed on them.

Note: Additional information relevant to this section is provided as the answers to Questions 57 and 58, in Addendum 5.

D. Permits: Prior to discharging drilling water into a storm sewer, obtain a permit from Delaware Department of Natural Resources and Environmental Control (DNREC) and pay any cost for said permit and any fees charged for discharging.

E. A factory calibration shall be conducted on all instruments prior to shipment. Certification shall be provided to indicate that the test equipment used for this purpose is calibrated and maintained in accordance with the test equipment manufacturer's calibration requirements and that, where applicable, calibrations are traceable to the National Institute of Standards and Technology.

F. A final quality assurance inspection shall be made prior to shipment. During the inspection, a checklist shall be completed to indicate each inspection and test detail. A completed copy of the checklist shall be supplied with each instrument.

G. The Contractor shall provide the manufacturer's warranty for each instrument, portable readout unit, data collection system components, and all materials used in establishing the instrumentation system.

1.05 JOB CONDITIONS

A. Graphical depictions of boring logs are included in the Drawings and detailed boring logs and laboratory test data are included in the Geotechnical Data Report (GDR) contained in the contract documents. The purpose of the GDR is to provide a description of subsurface conditions. The GDR does not necessarily indicate what the CONTRACTOR may find during his excavation. The CONTRACTOR is not to rely on the information presented in the GDR to develop his bid or plan the construction. New Castle County will not be liable for any damages or additional time/expenses due to the CONTRACTOR'S use and/or reliance on the information presented in the GDR.

B. Neither the Owner nor their representatives are in any way responsible for the safety and serviceability of the work. The Contractor is expected to make his own interpretations of the instrumentation data for his own purposes. Furthermore, the Contractor must install, monitor and interpret data from any additional instrumentation that the Contractor deems necessary to insure the safety and serviceability of the work.

PART 2 - PRODUCTS

2.01 EQUIPMENT

A. Cased Deep Benchmarks:

1. Black steel pipe, threaded couplings for two-inch inner benchmarks and 3-1/2-inch outer casings, ASTM A120, welded, extra-strong.

2. Read point consisting of two-inch diameter ball fabricated from approved grade of stainless steel.

3. Approved centering device between inner benchmark and outer casing as shown.

4. Protective concrete access box with lock-type heavy duty cover as shown. Furnish two wrenches for cover.

B. Surface Settlement Markers:

1. Vertical masonry-concrete surface type: Three piece expansion anchors, outer lead-alloy sleeve, inner lead-alloy wedge nut and stainless steel cap head bolt.

C. Inclinometer Casing, Sensor, Read-out and Cable:

1. ABS plastic having an outside diameter of 2.75 inches in lengths of 10 feet. Casing has 4 broached internal keyways equispaced 90 degrees apart and a twist tolerance of better than one degree per 10 feet length. The width and depth

of the keyways must be of such dimension that they are compatible with the wheels of the inclinometer sensor.

2. Couplings of size and type recommended by the casing manufacturer.

3. Provide protective concrete access box with lock-type heavy duty covers. Provide two wrenches for covers.

4. Provide a bentonite-cement grout mix as recommended by the manufacturer.

5. Biaxial Sensor meeting or exceeding the following:
   a. Two force balance accelerometers mounted at 90 degrees
   b. 2 feet wheel base
   c. Measurement Range: +/- 35° from vertical
   d. Resolution: 0.0012 feet per 2 feet
   e. Repeatability: +/- 0.003°
   f. System Accuracy: +/- 0.025 feet over 50 readings
   g. Temperature Range: -4 to +122°F
   h. Provide a protective carrying case for sensor

6. Provide accessories consisting of end caps, tools and materials for connecting probe to sensor and for taking readings.

7. Provide an inclinometer casing extension and cable support and pulley assembly.

8. Provide a solid state read-out unit compatible with the inclinometer sensor and capable of storing data internally without the need of magnetic tapes. The unit shall be capable of conducting statistical checks of the data immediately upon completion of each reading set to validate the acquired data. The unit shall be equipped with a serial port with RS232 signals.

9. Provide a cable sheathed with neoprene, with vulcanized rubber depth markers and an internal wire rope strain cord. Provide a cable of sufficient length to take readings at the bottom depths of all inclinometer casings.

D. Tiltmeter Plate, Indicator:

1. Bronze disc, at least 5.5-inches diameter with 4 protruding pegs.

2. Range: 30 degrees (+/-) from horizontal.

3. Sensitivity: 10 arc seconds.

4. Digital indicator compatible with sensor within accuracy of +/- 0.1 percent of reading.

5. Portable sensor compatible with tiltplate by means of alignment bars.

6. Zinc plated spun steel protective cover.

7. Tamperproof, expansion type anchors for attaching plate and cover.

E. Crack Monitoring Pins:

1. Vertical masonry-concrete surface type; three piece expansion anchors, outer lead alloy sleeve, inner lead alloy wedge nut and stainless steel cap head bolt.

2. Calipers for measuring between pins with accuracy to 0.001 inch.

F. Groundwater Monitoring Wells (Open Standpipe Piezometers)

1. Provide open standpipe piezometer slotted pipe well screens. Well screens shall be 2-inch Schedule 40 PVC pipe, 10 feet long, with 0.02 inch slots.

2. Provide riser pipe with vented top cap. Riser pipe shall be 2 inch Schedule 40 PVC with self-sealing flush joints. Joints shall either have modified pipe threads or O-rings such that they sustain an internal water pressure of 50 pounds per square inch. Standard square threads without appropriate O-rings are not acceptable.

3. Filter sand shall conform to ASTM C-778, Standard Specification for Standard Sand, for 20-30 sand.

4. Granular bentonite shall be Enviroplug Medium, as manufactured by Wyo-Ben, Inc., Billings, MT, or Holeplug, as manufactured by Baroid Division, Petroleum Services, Inc., Houston, TX, or acceptable equivalent.

5. CONTRACTOR must obtain appropriate permits from DNREC.

G. Seismographs (Blast Monitors)

1. Shall be four (4) channel [one (1) overpressure and three (3) seismic channels] units capable of digitally storing collected data including time histories, peak motion intensities, frequencies, time of recording, operator name, instrument number, and date of last calibration.

2. Uninterruptable power supply and backup power supply

3. Capable of digital recording and capable of transmitting data for immediate download and interpretation.

4. Capable of continuous monitoring for the entire duration of a blast event.

5. Instruments shall have a flat frequency response between two (2) and two hundred and fifty (250) Hz for particle velocity and from two (2) to two hundred (200) Hz for air-overpressure.

6. The digitizing sampling rate for peak particle velocity and air overpressure measurements shall be at least 1,024 samples per second.

7. Seismographs shall be capable of performing a self-test of velocity transducers and printed event records shall indicate whether or not the sensor test was successful.

8. Seismographs used for off-site compliance monitoring shall be capable of recording overpressure from one hundred (100) to one hundred forty-eight (148) dB-L, and particle velocity from 0.05 to 5.0 inches/second.

9. Seismographs shall have adequate memory to digitally record the entire duration of the blast-induced motion.

10. All seismograph/software systems shall be capable of saving back-up copies of all event files.

11. Refer to the International Society of Explosives Engineers 2009 Field Practice Guidelines for Blasting Seismographs for installation requirements for seismographs.

PART 3 - EXECUTION

3.01 INSTRUMENTATION INSTALLATION SCHEDULE

A. Install instrumentation prior to beginning excavation and construction.

B. Piezometers shall be installed and formal initial readings made no later than 60 days prior to any dewatering operations.

C. Inclinometers, deformation monitoring points, structure monitoring points, tiltmeter, crack gages, and deep benchmarks shall be installed and formal initial readings made no less than 14 working days prior to the start of any construction work.

3.02 INSTRUMENT LOCATIONS

A. Contractor to submit instrumentation and monitoring plan for approval. Plan shall include minimum requirements specified herein plus additional requirements as the contractor deems necessary for protection of adjacent facilities during execution of the work. The exact location of the instruments will be approved by the Engineer.

B. Locate benchmarks outside of the area influenced by the excavation as required. Provide a minimum of one cased deep benchmark.

C. General locations of surface settlement markers and tiltplates are on exterior walls of buildings, interior walls of underground vaults or surface features such as curbs.

Exact location of each surface settlement marker and tiltplate will be determined in the field.

D. Locations of crack monitoring pins will generally be on the walls of buildings. Location and numbers of crack monitoring pins as per 3.10.A. Inclinometer casings shall be installed at a minimum of 3 locations where gas utilities are within 5 feet of the planned excavated trench limits.

E. At a minimum, locate surface settlement markers at least every 100 feet on the nearest edge of the active travel lanes of Governor Printz Boulevard adjacent to the work.

F. A minimum of 3 seismographs shall be installed during the blast events locations affected by the blast on all affected structures. The CONTRACTOR shall submit proposed locations for each blast event a minimum of 1 day prior to each blast event.

G. Install groundwater monitoring wells on 100-foot longitudinal intervals at various distances from the dewatering source and transverse to the excavation in order to accurately show the radius of drawdown influence as imposed on areas adjacent to the construction by dewatering during any given phase of construction.

H. After instruments have been installed, or if damaged and reinstalled, prepare working drawings and reports summarizing location and installation of each instrument.

1. Show the following on working drawings:

a. Principal features of work and existing construction.

b. Established elevation of each cased deep benchmark and initial elevation of each surface settlement marker and inclinometer casing.

c. Instrument identification number and instrument type.

2. Show following on working drawings or in report form:

a. Procedure used for installation of each instrument and date of installation.

b. As-built configuration of each instrument including depths, lengths, elevations, location, and other dimensions of key elements of each installed instrument.

c. Verification that inclinometer casing meets specified tolerances for alignment of longitudinal grooves and vertical inclination.

I. The Contractor shall provide inclinometer casing at a minimum of three locations where gas utility alignments are within 5 feet of the planned excavated trench limits.

3.03 PREPARATION

A. Provide traffic control during instrument installation according to applicable regulations of local municipalities, state, and the Delaware Department of Transportation (DelDOT).

B. Protect existing facilities, including but not limited to the following, from damage prior to, during, and subsequent to instrument installation:

1. Street lights.
2. Existing structures.
3. Pavement and road medians.
4. Existing underground and overhead utility lines shown on the Drawings.

3.04 INSTALLATION OF CASED DEEP BENCHMARKS

A. Install cased deep benchmarks as shown by the approved monitoring plan.

B. Drive outer casing vertically to required elevation. Drill ahead of outer casing as required to penetrate dense soil strata.

C. Seat outer casing at two feet above tip elevation.

D. During assembly and lowering into outer casing, install centering devices between inner benchmark pipe and outer casing as shown.

E. Prepare and cut bottom one foot of inner pipe. Drive inner pipe until split ends have reached full depth, and are spread and gripped into sides of hole for positive anchorage; test and check for anchorage and pullout; if pipe can be pulled out, redrive until securely anchored.

F. Pump bentonite slurry into annular space between inner and outer pipe completely filling space. Cut pipes at correct height and install top centering device and disk.

G. Weld stainless steel ball read point to top end of benchmark pipe.

H. Install protective access box and cover over end of outer casing. Lock the box cover.

3.05 INSTALLATION OF SURFACE SETTLEMENT MARKERS

A. Install settlement markers as shown by the approved monitoring plan.

B. Masonry-Concrete Surface Type

1. Drill correct diameter and depth hole into receiving surface.
2. Blow out drilling debris from hole.
3. Assemble expansion anchor and insert into hole.
4. Tap outer sleeve onto wedge nut to effect initial sleeve contact with wall of hole.
5. Expand outer sleeve into tight contact with wall of hole by turning until anchor is rigid within hole. Do not strip wedge nut threads by excessive turning of bolt.

3.06 INSTALLATION OF INCLINOMETER CASING

A. Install inclinometer casing as shown by the approved monitoring plan.

B. Install inclinometer casing approximately 5 feet outside face of Temporary Earth Retention Structure, starting at the outside ground surface and penetrating to a depth of not less than 20 feet below final bottom of excavation or top of rock, whichever comes first.

C. Drill a six-inch diameter hole to receive inclinometer casing. Verify that hole is drilled such that inclinometer casing when installed will meet vertical inclination tolerances.

D. Tremie grout annular void.

E. When a drill hole will not remain open, advance the drill hole utilizing a steel outer casing or drilling mud. When steel outer casing is used, withdraw said steel casing after installation of inclinometer casing. Perform tremie grouting operation of annular void during the withdrawal of the steel casing to prevent the formation of voids in the annular ring. Steel outer casings remain the property of the Contractor.

F. Cap and seal watertight the bottom end of the bottom section of inclinometer casing. Insert bottom section of casing in drill hole. Couple succeeding sections of inclinometer casing to preceding sections. Assure that couplings affect a watertight seal to casing sections.

G. Add clear water to inside of inclinometer casing to facilitate lowering of inclinometer casing into water or drilling mud in drill hole, or to prevent flotation of inclinometer casing in a dry drill hole should water enter the drill hole prior to grouting of the drill hole.

H. Install inclinometer casing so that one grooved axis of casing is perpendicular to the excavation.

I. Cap top of casing to prevent entry of water.

J. Survey casing for spiral prior to collecting initial data. Include corrections for as-built spiral in initial and subsequent monitoring calculations. If spiraling of casing is too severe to correct for, as determined by NCC, replace installation at no additional increase in the contract price.

K. Using tool similar to fine, 32-teeth per inch hacksaw blade, saw well defined X on end of inclinometer casing for survey reference with intersection of legs of X at center of casing wall thickness. Place X midway between adjacent grooves.

L. Install protective boxes over ends of installed inclinometer casing. Lock the coverbox. Provide the Engineer with keys to the coverbox locks.

3.07 INSTALLATION OF TILTPLATES

A. Install tiltplates in such manner that a pair of diagonally opposite pegs are vertical and both perpendicular and parallel to the monitoring surface.

B. Mount tiltplate, in approved location, with expansion type threaded anchors. Do not strip wedge nut or deform the bronze plate by excessive tightening of the anchor.

3.08 INSTALLATION OF CRACK MONITORING PINS

A. Install one pair of crack monitoring pins at locations mutually agreed upon by the Contractor and the Engineer.

B. Install pins far enough away from the crack such that pin installation will not interfere with the crack or cause further cracking.

3.09 INSTALLATION OF GROUNDWATER MONITORING WELLS

A. The groundwater monitoring wells should allow for the accurate measurement of groundwater before, during and after the dewatering operation.

B. The annulus between the borehole and the riser pipe shall be backfilled with clean sand.

C. The top of the monitoring well shall be sealed with a non-shrink bentonite slurry to prohibit the infiltration of groundwater into the well.

D. CONTRACTOR shall obtain appropriate permits from DNREC.

E. Monitoring wells should be plugged prior to final acceptance of the Work.

3.10 SURVEY CONTROL

A. Establish cased deep benchmarks from County (DelDOT) benchmarks to tolerance specified.

B. Establish elevation of cased deep benchmarks by running level circuits started and closed at County (DelDOT) benchmarks.

1. Use three-wire leveling methods.

2. Establish turning points during leveling so that foresight and backsight distances are approximately equal.

3. Use turning points consisting of well-defined surface points of solid objects or masonry nails driven into pavement.

4. Do not exceed sight distances of 100 feet.

5. Achieve level circuit closures with error-of-closure less than 0.01 foot. If error-of-closure greater than 0.01 is achieved for any level circuit, resurvey circuit.

6. Adjust optical survey data for circuit closure error by dividing error by number of setups and distributing quotient equally among turning points.

7. Prove established elevations of cased deep benchmarks. Run at least three separate and complete level circuits which yield consistent results.

a. Should an inconsistent elevation for any deep benchmark result, resurvey level circuits until correct and repeatable elevations are obtained.

C. Establish above points prior to start of excavation.

D. Establish initial elevations of surface settlement markers and subsurface settlement indicators from cased deep benchmarks. Determine elevation from multiple base reference readings.

E. Check elevation of cased deep benchmarks every month.

3.11 INSTRUMENT MONITORING

A. Formal Initial Reading:

1. Obtain initial elevation readings on surface settlement markers and inclinometer casings. Prove initial elevations.

2. Obtain at least three separate and complete sets of initial readings on each instrument which yield consistent results.

3. Should an inconsistent initial reading on any instrument result, reread instrument until correct and repeatable initial readings are obtained.

B. Survey Methods:

1. Use survey methods for reading of instruments as specified for survey control.

2. Obtain initial and subsequent elevations of instruments by running level circuits started and closed at cased deep benchmarks.

C. Monitoring Frequency: Monitor instruments in accordance with the following:

1. Daily, monitor each surface settlement marker, each pair of crack monitoring pins and each tiltmeter plate when excavation is in progress within 100 feet of each instrument. Otherwise, monitor instruments on a monthly basis.

2. Daily, monitor each inclinometer when excavation is in progress within 100 feet of the inclinometer, each time after a support element is installed or removed, and each time after a lift is excavated. After completion of the excavation, monitor each inclinometer daily for the next two weeks; weekly for the next two months; and monthly thereafter until the excavation is closed and the temporary earth retention structure is removed.

3. Bi-daily, or when the pumping rate of the groundwater control system changes by more than 10% of the average daily pumping rate, monitor groundwater observation wells.

D. Instrumentation Monitoring Threshold Values:

1. Implement Response Action Plans as specified in Article 1.03 (F) above when instrumentation data indicate adverse settlement, movement, and/or loadings as specified below.

2. Instrumentation monitoring threshold values are the amounts of movements which, if exceeded, require the implementation of approved Response Action Plans as submitted in accordance with Article 1.03.F above.

3. Level 1 Alert Threshold Response: When any threshold value is exceeded, the Contractor shall immediately notify the Engineer and Owner and start modifying the construction procedure. Measurement of displacements or vibrations exceeding maximum allowable Level 1 Alert Threshold displacements shall trigger the mandatory evaluation by the Contractor and the Engineer of current construction methodology and if necessary, implementation of mitigative action to avoid detrimental effect on the surrounding facilities and groundwater regime. Upon reaching or exceeding the Level 1 Alert Threshold, Contractor will immediately undertake the measures defined in the Response Action Plan and shall implement all necessary steps so that the Level 2 Upset Limiting is not reached.

4. Level 2 Upset Limiting Response: Measurement of displacements or vibrations exceeding allowable Upset Limiting displacements shall trigger the mandatory cessation of Work in the area of concern and will immediately require implementation of all necessary mitigative action to prevent damages to surrounding facilities and changes to the groundwater regime, as defined in the accepted Contractor's Response Action Plan.

5. Inspect buildings and monitor for damage. Inspect buildings on a daily basis when construction is within 100 feet of the building; otherwise, inspect on a weekly basis. Include identifying, marking and measuring cracks. Implementation of the same actions required for measurements exceeding the Level 2 threshold values is required if existing cracks increase in width by 1/8 inch or more, or if new cracks greater than 1/8 inch are observed

6. Level 1 Alert threshold values:

a. Surface settlement markers:	0.375 inch
b. Inclinometer casing movements:	0.5 inch
c. Tiltmeter plates:	0.0005 (0.0286 degrees)
d. Crack monitoring pin:	1/16 inch
e. Seismographs: As indicated in Section 02316	1 inch per second

7. Level 2 Upset threshold values:

a. Surface settlement markers:	0.5 inch
b. Inclinometer casing movements:	0.75 inch
c. Tiltmeter plates:	0.001 (0.0573 degrees)
d. Crack monitoring pin:	1/8 inch
e. Seismographs: As indicated in Section 02316	2 inches per second.

8. Maximum allowable displacements above shall refer to net allowable change in displacement relative to respective initial positions of all ground, buildings, and structures immediately prior to the outset of field activities by the Contractor under this Contract.

9. Maximum allowable displacements shall be considered to have been exceeded if they are exceeded at any location, floor, column, component, or position within any given building, structure or utility.

3.12 AVAILABILITY OF DATA

A. Do not disclose instrument-monitoring data to third parties and do not publish instrument-monitoring data without prior approval of NCC.

B. The Contractor is expected to make his own interpretations of instrument-monitoring data for his own purposes.

C. The Contractor may observe the readings at any time, or take supplementary readings at no additional cost to NCC. All data collected by the Contractor must be made available to NCC.

3.13 INSTRUMENT PROTECTION, MAINTENANCE AND REPLACEMENT

A. Protect and maintain instruments. Drain water or flush debris from under protective covers. Keep protective covers locked.

B. Provide approved substantial protective barriers as required around cased deep benchmarks and around subsurface settlement indicators.

C. Repair or replace damaged or missing instrument components or entire instruments as required within five days at no additional cost to NCC.

3.14 DISPOSITION OF INSTRUMENTS

A. Prior to final acceptance of work and subject to approval of NCC, remove and dispose of all surface settlement markers, tiltplates and top two feet of inclinometer casing in earth together with protective boxes and covers.

B. Fill, with Portland cement mortar, holes drilled in masonry or concrete surfaces for surface settlement markers, tiltmeter plates and crack monitoring pins.

C. Plug remaining open portions of inclinometer casing with Portland cement concrete. Backfill casing excavations with suitable material. Construct new pavement patches in paved areas of the same material and to the same thickness as existing and adjacent pavement.

D. Restore disturbed or damaged surfaces to conditions existing prior to installation of instruments.

E. Remove painted instrument identification numbers from building and other surfaces. Remove wooden markers and protective barriers.

   a. Upon completion of Contract, leave cased deep benchmarks in place. Set cased deep benchmark protective covers flush with pavements or finished grade.

3.15 FORMAL INITIAL MONITORING

A. Formal initial readings shall be agreed upon between the Contractor and Engineer by taking simultaneous readings and agreeing on their consistency.

END OF SECTION